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Beetlemania: How a supergroup scuttled to world domination

Handsome, hardy and diverse, beetles are supremely successful critters with a lot to teach us – but they're suffering from our environmental waywardness

Whether earth, sky or twig, there are few domains beetles haven't conquered. Above: ox beetle, *Strategus aloeus*
Alex Wild

By **Richard Jones**

WHEN biologist J.B.S. Haldane was asked by a theologian back in the 1940s what we could infer about the mind of the creator from the works of creation, he supposedly replied, "an inordinate fondness for beetles". The story is almost certainly apocryphal, but it reveals both an undeniable truth and an open question. Judging by their sheer numbers, God is certainly fond of beetles. But just how fond?

The number of beetle species is just one lacuna in our knowledge of these extraordinarily successful creatures. Another is what makes them quite so successful. As we slowly fill in the gaps, we are beginning to appreciate the unique insights these insects can give us. Whether we want to understand evolution, the workings of the biosphere or how plate tectonics has shaped the continents, beetles hold the answers.

But let's deal with the numbers question first. New beetle species have been described at an average rate of about four a day since 1758, when Carl Linnaeus started cataloguing plants and animals using the two-part Latin scientific names we know today. Towards the end of the 20th century, there was general agreement that the total count was heading towards 400,000 species, based on specimens housed in the world's museums and carefully documented in 250 years of scientific journals and monographs. Compare that with 5500 mammals, 10,000 birds, 85,000 molluscs and 250,000 plant species, and it is clear that in diversity beetles far outstrip any other multicellular organisms, perhaps quietly brushing aside nematode worms.

In 1982, however, this emerging consensus was shaken to the core. Entomologist Terry Erwin was conducting a census in the Panamanian rainforest, hauling fogging machines up into the canopy and retrieving the insects that fell from the branches in bins and sheets below. From just one evergreen tree species, *Luehea seemannii*, he collected 1200 species of beetle, some unknown to science. Using simple mathematics and modest assumptions about how some beetles were specific to certain trees, he extrapolated the number of beetle species present in all 50,000 known tropical tree species. It came out at around 12 million.

Read more: Five amazing beetles from around the world

Using slightly different ecological assumptions, others came up with anything from 3 to 33 million beetle species. This was bonkers. Not only was the deity's love of beetles far more ardent than anyone thought, but our estimates of that ardour were now at odds by more than an order of magnitude. Although arguments still rage, most models seem to agree that there are at least a few million beetle species.

So why are beetles so successful? We have long had ideas, but only recently did they gain some experimental backing.

Beetles began to proliferate in the Carboniferous period between 350 and 300 million years ago. At some point the front pair of wings of their precursor beetloid acquired a leathery texture, while the hind pair remained delicate and membranous. The tough front wings gave protection to the folded back wings when the creature shimmied into a tight crevice under a bit of loose cycad bark or a fallen tree fern. With the insect still able to fly at will, these structures became indispensable armour – the elytra, or wing cases, of modern beetles.

In what has become an instant classic of the entomological literature, in 2016 David Linz of Indiana University Bloomington and his colleagues tested the importance of the elytra by exposing beetles to various environmental stresses. Surgically trimming the wing cases from the red flour beetle, *Tribolium castaneum*, they measured damage over time to the membranous hind flight wings, survival against attack by *Pardosa* wolf-spiders, whether the beetles dried out in low humidity, and how the beetles coped in -4°C cold for 24 hours. In all cases, morbidity and mortality were greater in the trimmed beetles than in intact specimens. The elytra really were life-saving armour.

Terry Erwin's rainforest fogging experiments reveals undreamed-of-beetle diversity
Mark Moffett/Minden Pictures/Alamy

Beetles enjoyed one other lucky break: the advent of flowering plants between 120 and 100 million years ago. Their emergence seems to have led to beetle species increasing 600-fold. Today, the main plant-feeding beetle groups are the Phytophaga – leaf beetles, longhorns and weevils. Their 135,000 species, making up 80 per cent of all catalogued herbivorous beetles and half of all herbivorous insects, mostly feed on flowering plants. They will feast on just about any plant part, too, from tubers, roots, shoots and bark to leaves, buds, flowers, seeds and fruits.

But in certain temperate parts of South America, South Africa, Australia and New Zealand, a few ancestral species – just 225 in total – feed on "primitive" non-flowering plants such as conifers and cycads, which dominated Earth's earlier flora. The nutrient-rich, pollen-bearing male cones (strobili) of conifers are the staple of most of these insects.

"Beetles' persistence and ubiquity make them unique witnesses of ecological change"

Beetles' hardiness and dietary flexibility means they have come to thrive in a quite extraordinary range of environments. A world away from the exuberant beetle throngs in the cloud forests of Central America, for example, beetles form the main plank of biodiversity in one of the driest places on Earth, the Namib desert (see "Beetlemania: Five amazing beetles from around the world"). Wherever they occur, their ubiquity and persistence make them unique witnesses to ecological continuity and the mechanisms of environmental change.

Evolution pioneer Alfred Russel Wallace's beetle collection is in London's Natural History Museum
NHM Images

Perhaps the best studied beetle fauna – in fact, perhaps the best studied of any fauna anywhere – is found in the British Isles. Both the progenitors of the theory of evolution by natural selection, Charles Darwin and Alfred Russel Wallace, were avid coleopterists, and many have walked in their footsteps since. The UK and Ireland have, in global terms, a small, well-catalogued tally of beetle species, at just over 4000. A crushing ice sheet covered the islands as recently as 13,000 years ago, and rising sea levels then cut them off from continental Europe before many beetles could recolonise.

In the UK, "saproxylic" wood and fungus-eating beetles are being used to identify truly ancient woodlands in a citizen science project. Such woods are usually those reckoned to have had continuous tree cover since at least 1600, although this is hard to confirm as maps are barely accurate until the mid-19th century. The uninterrupted supply of different timbers of all ages being recycled by fungi, and in all stages of rot and decay, offers an intricate complexity of microhabitats and niches for beetles that occur nowhere else.

Dryophthorus corticalis, for example, is a small earth-brown weevil that lives, often with the scarce tree ant *Lasius brunneus*, under crusty fungoid oak bark. The weevil is known only from a narrow band of land between Richmond, Windsor and Slough to the west of London. Then there is the Moccas beetle, *Hypebaeus flavipes*, found on just a few old trees in Moccas Park national nature reserve in Herefordshire near the Welsh border.

Surveys of nearly 600 scarce and highly restricted species, and the richness and variety of their communities, have now been turned into an interactive online league table of

Every gardener's best friend: ladybirds or -bugs are more than just pretty faces
Redmond Durrell/Alamy

Britain's top 200 ancient woods for saproxylic beetles. Not surprisingly, some of the largest, best known and best documented ancient woodlands score highest, with the royal hunting grounds of Windsor Forest and the New Forest in the south of England jostling for top position. But 76th on the chart is Sydenham Hill Woods deep in suburban south-east London, a suspected remnant of the medieval Great North Wood. Just a few kilometres away, at number 127 on the list, is Downham Woodland Walk, a wooded footpath zigzagging through a 1930s housing estate. It is no doubt the remains of an ancient shaw hedgerow following Elizabethan field boundaries. Easily threatened by development or habitat corruption, the beetles of such fragments are evidence of genuine relic communities, ones that need protection and proper management.

The way individual beetle species tend to inhabit specific ecological niches makes them particularly good indicators of overall ecosystem health around the world. Diversity in a water beetle community indicates good freshwater quality, for example, whereas agricultural run-off and industrial contaminants can leave ditches lifeless or with just a few common pollution-tolerant species.

Beetles can also tell us things that other species cannot. On chalk downs, limestone pavements, sandy heaths or maritime cliffs, the presence of scarce, specialised plants is a welcome sign of a healthy ecosystem. But plants may reappear after years or decades from seeds that have lain dormant. The presence of equally scarce, plant-dependent beetles with their short, mostly annual, life cycles signifies genuine ecological continuity.

Conservation efforts rely on these formal appraisals of what species occurs where, and why. *Drosophila* fruit flies may be the geneticist's choice of lab animal, and butterfly-counting transect walks may be popular and useful, but nothing beats beetles as a yardstick for changes to the planet over time. A classic example is the way Victorian travellers were struck by the similarity in brightly coloured chafer and jewel beetles in West Africa and South America, and their dissimilarity either side of the Wallace line between the South-East Asian islands of Borneo and Sulawesi. Plate tectonics later gave an explanation: when beetles were proliferating, these continental areas were joined in the first case, and widely separated in the second.

Today beetles are the coal-mine canaries for climate change. By comparing cold-adapted ground beetle faunas collected from Ecuadorian mountains in 1880 with those from the 20th and 21st centuries, we have learned that the unique communities of the high-tundra "paramo" habitat have been diminishing, pushed further up the warming slopes. Eventually, many of these species, adapted over millions of years, may run out of mountain. Meanwhile, in the Netherlands, a survey between 1980 and 2004 of two-spot ladybirds showed how blacker, "melanic" forms that were better adapted to colder temperatures inland are being displaced by the red spotty forms that used to be found only on the balmier coasts.

With their awe-inspiring diversity, handsome, chunky forms and often bizarre life histories, beetles are colourful guides to ecological change, helping us understand that the world revolves not around us, but around much smaller, more important creatures. But they sound a warning note, too. A report earlier this month from the International Union for the Conservation of Nature says that nearly a fifth of saproxylic beetles in Europe – those very symbols of ecosystem continuity – are in danger of extinction, following the continued loss and fragmentation of ancient woodland landscapes.

When it comes to the question of the true number of beetle species out there, the sad fact is that we shall almost certainly never know: our less-than-exemplary custodianship of the world's biodiversity means that, if we continue as we have been, most will be extinct before we find or name them.

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